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and the "mean sea level" datum adopted by the United States Coast and Geodetic Survey in the establishment of the base net of the United States. Mr. John R. Freeman, Chief Engineer for the Charles River Dam Committee, in his report published in connection with the report of that committee in 1903, includes much data concerning the Charlestown Dry Dock bench marks, the various datums in use and the probable coastal subsidence in this vicinity.

Extensive engineering projects such as the construction of metropolitan sewerage systems, development of water supplies for groups of municipalities, hydro-electric developments, etc., have shown the importance of precise levels referred to a *common datum.* Such a system covering the entire state would furnish a comprehensive level net, to which the leveling of the various municipalities could readily be tied through the accurate determination of the difference in the respective datums. The United States Coast and Geodetic Survey has this as one of its objectives, and the present line of levels between Providence and Portland is an important step in this direction. It is the intention of the Coast and Geodetic Survey to re-run the line of the Van Orden levels, using the present precise methods which have been developed, and also to run a line up the Connecticut Valley from Springfield, Mass., to St. Johnsbury, Vt., when funds are available.

Members of the Society are urged to take an active interest in this work and to co-operate whenever possible in order that Massachusetts and the other New England states may derive the advantages which will accrue from such a co-ordinated system of levels.*

DURING the seasons of 1922 and 1923 about 850 miles of precise leveling were completed in New England by the United States Coast and Geodetic Survey, some 500 miles of which were executed by the writer in 1923. This leveling connects with previously determined points in the base net of the United States at three places, — Yonkers, N. Y., Poughkeepsie, N. Y., and Rouses Point, N. Y., and is rigidly adjusted to the base net. This work has been done in conformity with the Coast and Geodetic Survey instructions for precise leveling, and its accuracy is of the highest order obtainable under our present knowledge of the subject.

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* Additional leveling of a fairly precise character has been recently done by the United States Geological Survey in connection with the control of topographical mapping at Camp Devens, Mass. About 134 miles of levels were run and numerous bench marks established in towns in the vicinity of Camp Devens. Although space does not permit the publication of this data, complete information is on file at the library of the Boston Society of Civil Engineers.

PRECISE LEVEL NET OF THE UNITED STATES

In the early history of the United States Coast and Geodetic Survey it became expedient to connect the coastal surveys on the east and west coasts in order to reduce all surveys in this country to a common datum. Accordingly, the "Transcontinental Arc" of precise triangulation was established. To strengthen the connection and to extend the area covered by precisely located points, which were found very useful by local engineers, the execution of other arcs was begun. In order to have information for applying sea level reductions, essential in adjusting the work, the Coast and Geodetic Survey started running lines of accurate levels. It was found that the elevations thus obtained were useful to topographers using the triangulation points mentioned, as well to other surveyors and engineers in the vicinity. The value of this work was so great that a careful study of leveling was undertaken, in order that long distances might be covered without large accumulations of errors. The methods of working have been gradually improved and standardized and at the same time large additions have been made to the level net.

Over 48,000 miles of precise leveling have now been run in the United States. Of this amount the Coast and Geodetic Survey has done about 32,000 miles, — the remainder having been done by the United States Geological Survey; the Corps of Engineers, United States Army; the Mississippi River Commission; the Missouri River Commission; the United States Lake Survey; the Pennsylvania Railroad; the Baltimore & Ohio Railroad; and the Buffalo, Rochester & Pittsburgh Railway. This vast network of leveling enters all the States of the Union but one, and forms over one hundred closed circuits. It is desired ultimately to have the net cover the country in such a way that every point in the United States will be within fifty miles of a standard bench mark.

In many cases it will be found that the presence of the standard bench marks makes unnecessary the running of long lines of levels by engineers, notably in the cases of railroad companies whose lines have been followed. Leveling in connection with hydraulic or other projects may be checked and controlled by tying in with standard bench marks at different places. The greatest value of the level net lies, however, in its scope as a nation-wide base net. By means of this vertical control and the basic horizontal control by which the country is covered, local surveys can be reduced to a common datum, will be consistent among themselves, and will require little adjustment when joined together in a harmonious whole. The value of such co-ordination is so obvious as to need no discussion.

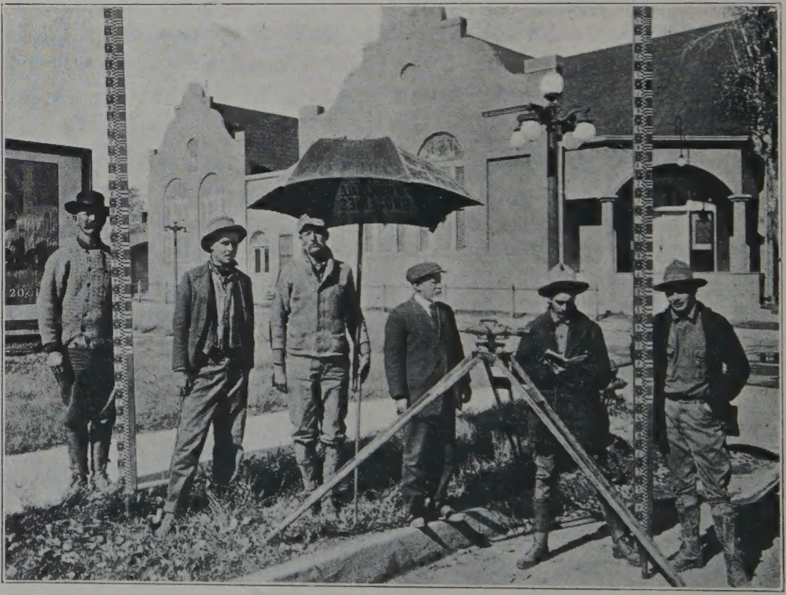

FIG. 1. — PRECISE LEVELING PARTY OF UNITED STATES COAST AND GEODETIC SURVEY AT ROSWELL, N. M.

There have been four general adjustments of the precise level net of the United States, each succeeding adjustment having become necessary by the addition of new lines to the net. The fourth and last adjustment was made in 1912, the net at that time being composed of about 29,000 miles of leveling.

The successive adjustments necessarily gave different values for the elevations of the bench marks, and the changes in certain sections of the country were of such magnitude that the older values could not be retained. The last adjustment shows that the net is sufficiently extended and the leveling of such strength and accuracy that the elevations may be considered as standard. So far as surveying and engineering purposes are concerned, they may be held for all time.

The lines run since the last adjustment have been fitted to the net, *i.e.*, adjusted within themselves only, without in any way disturbing the previously adopted elevations.

From time to time in the future, general adjustments of the level net will no doubt be made to obtain the theoretically best elevations of the junction points, but such adjustments will not disturb the standard elevations, unless they are found to be appreciably in error on account of blunders in the leveling or because of the disturbance of the marks.

Mean Sea Level Datum. — The elevations of all bench marks in the precise level net of the United States are referred to mean sea level, which is the average height of the surface of the sea, all stages of the water considered. It is the surface that the water of the ocean would form were it not disturbed by the attraction of the heavenly bodies and the force of the wind.

Mean sea level is usually determined from hourly height readings. In recent years automatic tide gages, which make a continuous graphic record, have been in use at all important points. By means of continuous observations extending over at least a year the mean sea level may be determined within a very small fraction of a foot.

In adjusting the level net of the country it is assumed that mean sea level is at the same elevation on the open coasts of the Atlantic Ocean, the Gulf of Mexico, and the Pacific Ocean. This assumption may not be strictly true. There seems to be evidence accumulating to show that there is a slight rise in mean sea level to the northward, which cannot be explained at present. There may be also a difference between the elevations of mean sea level on the Atlantic Coast and on the Pacific Coast. Slight errors may, furthermore, be introduced through our inability at times to place our tide gages in perfect locations, away from the influence of river flow, wind tides in harbors and sounds, or other disturbing phenomena. In general, however, the closures on mean sea level, between tidal stations, compare very favorably with the closures of inland circuits. Any uncertainty, therefore, in mean sea level, which is so small as to be obscured within the uncertainties of our leveling, is obviously not of great import to the engineer making use of standard elevations.

The Orthometric Correction. — The orthometric correction is applied to the results of all precise leveling. This correction eliminates from the observed results the effect of the convergence of level surfaces as the poles of the earth are approached. It will be remembered that the earth is an oblate spheroid, and a section taken through the axis of the earth will be an ellipse with the minor axis coinciding with the axis of the earth. The resulting elevations are the vertical distances of the points above sea level.

This correction has its greatest effect on a north and south line, and is directly proportional to the elevation of the line. On an east and west line of levels it is zero. In the New England states, where the elevations are low, this correction is small, and on the line from New York to Portland, which is practically at sea level, it is zero.

An instance of this correction on a long and high north and south line is between San Diego, Calif., and Seattle, Wash., via Goffs, Calif., Ogden, Utah, and Pocatello, Idaho, on which the total correction amounts to 1.2414 meters (4.0728 feet). The correction is negative going northward.

Accuracy. — The correction necessary to close the circuits of leveling averages about 0.12 millimeters per kilometer of distance around the circuit, or about $\frac{3}{4}$ inch per 100 miles. The work done in New England follows closely this average as to closures.

PRECISE LEVELING IN NEW ENGLAND

A glance at one of the accompanying sketch maps will show the extent of the leveling already completed in New England. The line from New York City via Yonkers to Rouses Point, N. Y., lies wholly in New York state and was completed in 1921. In the adjustment of this work the connection points at Yonkers,

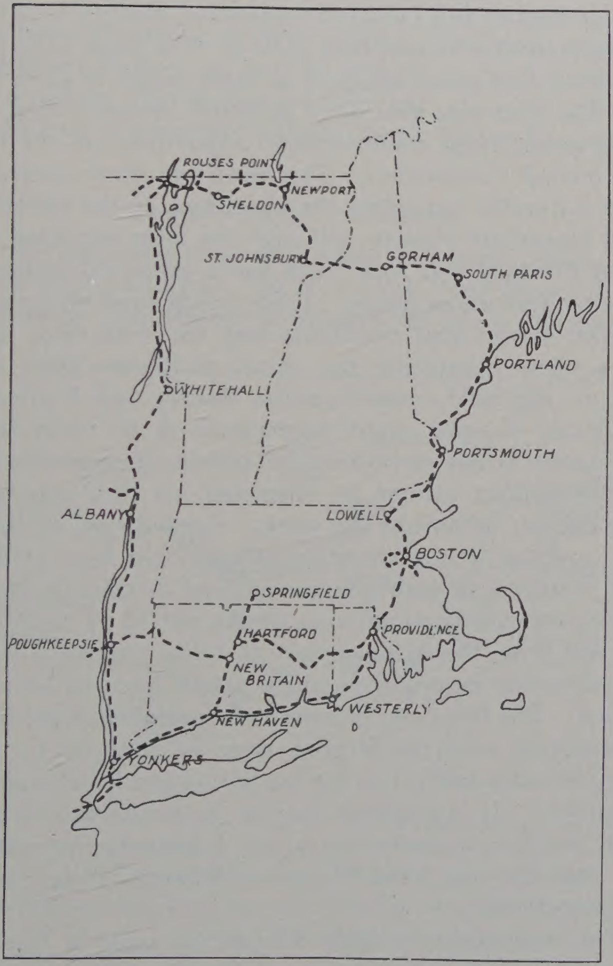

FIG. 2. — PRECISE LEVELING IN NEW ENGLAND.
The heavy broken line shows the route taken by the United States Coast and Geodetic Survey. The accompanying article refers particularly to the leveling between Portland, Me., and Providence, R. I.

Poughkeepsie, and Rouses Point were held fixed in accordance with previous adjustment of this earlier work. The tidal bench marks at Boston and Portland (connected directly to tide gages at those points) were also held fixed at their basic values on the assumption that mean sea level at these points is at *zero* elevation. The lines run were then adjusted between these points, due allowance being made for loop adjustment on the two circuits crossing Connecticut. The mean sea level connection at Boston naturally controlled the elevations of the bench marks in that immediate vicinity, although the mean sea level connections at Portland and New York had a slight effect due to the closure between those places. There would have been very little difference in the final elevations had the work been adjusted from Yonkers throughout the circuit to Rouses Point without regard to the tidal connections at Boston and Portland. In spite of the possible slight uncertainty as to mean sea level being exactly at *zero* elevation at all points, the evidence of these tidal connections cannot be neglected, as they are certainly strong enough to control the work. Furthermore, if there is a slight variation in the elevation of mean sea level at different points, connections with a larger number of tidal bench marks, and the consequent adjustment of the net to fit these connections, will bring the datum nearer to being a mean of mean sea level elevations everywhere, which would seem to be the ideal situation. The line from Hartford to Springfield was connected at Springfield with the leveling done in 1893 by C. H. Van Orden, and adjusted values for the Springfield bench marks were determined.* It is probable that in the future this line will be carried north to a connection at St. Johnsbury, Vt. It is also likely that the line from Boston to Albany will be run, using modern methods.

The comparatively large amount of work in Connecticut was undertaken by the Coast and Geodetic Survey at the request of, and in co-operation with, the Connecticut State Highway Department and the United States Geological Survey. At the same time a large amount of single run leveling in closed circuits was executed in Connecticut by the Geological Survey.

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* See Introduction.

The unusual amount of detail work in the vicinity of Boston as shown on the accompanying diagram was performed in order to provide strong connections between the leveling of various organizations operating in that region. The large amount of leveling about Boston can now be reduced to the United States standard datum, the various separate nets thus becoming consistent with each other and with the Coast Survey base net.

Connections at Boston

At Boston connections were made with bench marks of the Boston & Maine Railroad; the New York, New Haven & Hartford Railroad; the Boston & Albany Railroad; Boston City leveling; Cambridge City leveling; Massachusetts Institute of Technology; C. H. Van Orden levels; United States Coast and Geodetic Survey tidal bench marks at Charlestown and South Boston; United States Weather Bureau, and the United States Navy Department.

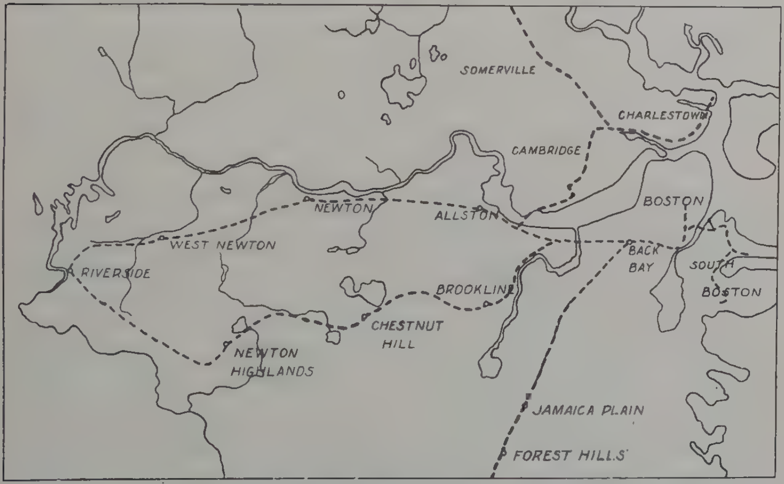

Fig. 3. — Precise Leveling in Boston and Vicinity.
The heavy broken line shows the route taken by the United States Coast and Geodetic Survey.

There has been a great deal of confusion existing in Boston for many years due to unexplained discrepancies in the leveling of different organizations, as well as to apparent changes in elevation of important bench marks at different points. Several careful studies have been made but the situation has never been cleared up satisfactorily. Important in this connection may be mentioned two tidal bench marks at the Charlestown Navy Yard Dry Docks, long used as basic bench marks for Boston. These show progressive changes of elevation between themselves and with relation to mean sea level. One authority has presented the theory that upheaval of the bench marks has taken place due to expansion of the joints in the dry dock masonry and, also, that there is taking place a slow subsidence of the entire coastal plain about Boston.* There seems to be good evidence to support his theories. The writer believes that many bench marks about Boston are subject to change due to local settling, parts of the city being built on extremely unstable ground. Such may be the case at Cottage Farm, where important bench marks are located. This entire question, however, is a matter of controversy, and no attempt will be made to discuss it in this paper.

The leveling performed in Boston in 1923 by the United States Coast and Geodetic Survey should be of great assistance in future studies of elevations in Boston. A connection was made with tidal bench marks established after two years of careful tidal observations at Commonwealth Pier, which should allow the reduction of all Boston elevations to the best possible present mean sea level determination. Some of these tidal bench marks are in high locations in South Boston free from any suspicion of local settling. A very important connection was that made with a bench mark in the South Boston Dry Dock, a metallic rod, within a pipe in the dry dock wall, extending down to and firmly embedded in bed rock. A knowledge of the relation of such a bench mark to mean sea level over a period of years should be of value in studying the question of coastal subsidence. The same question may also be studied by means of the bench marks on the lines approaching Boston, more or less perpendicular to the coast line, extending back into higher country, and supposedly free from subsidence. The connecting together with unquestionable accuracy of many of the important bench marks and the present mean sea level gives a clear picture of the situation as it existed in 1923. That, at least, is something definite to make use of in future studies.

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* Report of John R. Freeman, Chief Engineer of Committee on Charles River Dam, 1903.

Popular Approval of the Work

Throughout the execution of the New England leveling a great deal of interest in the work, and a desire to be of assistance, was shown by engineers and the public with whom the writer came in contact. This was particularly true in Boston, where help was received from the engineers of the railroads, the city engineering department, and other organizations. Special credit must be accorded to the Boston Society of Civil Engineers, which acted as a co-ordinating agency, and which, through the efforts of its secretary, was responsible for the thorough treatment of the situation at Boston.

Method of Carrying on the Work

Instruments. — A photograph is shown of the latest type of leveling instrument used on this class of work. It is built largely of invar (nickel-steel alloy with very low temperature coefficient of expansion) to prevent distortion of the instrument due to unequal heating. The telescope is irreversible and is supported on trunnions over the vertical axis of the instrument and on the point of a micrometer screw near the eyepiece end. The arrangement of three leveling screws prevents strain and consequent distortion in the base and is easier and quicker to operate than the four-screw arrangement, commonly found on engineers' instruments. The level vial is set into the barrel of the telescope, and covered by a glass window in the outer supporting cylinder. By means of a mirror and two small prisms an image of the two ends of the bubble, as seen against the scale on the tube, may be seen with the left eye without moving from the observing position. The instrument is leveled approximately, by means of either the small universal level on the right side or the observing bubble, then brought to an exact level by means of the micrometer screw supporting the eyepiece end of the telescope. This can be done very rapidly by an experienced observer, who can, moreover, control the level of the instrument at the same time he is making his readings, without a conscious shifting of his attention. The readings are made with each of three horizontal cross wires, equally spaced. The attainment of two equal intervals between these three readings is a check on the accuracy of the reading. The instrument requires shading while reading and while being carried forward, to prevent unequal heating of the bubble or supporting members. The only field adjustment required ordinarily is the peg adjustment for parallelism of level vial and line of collimation.

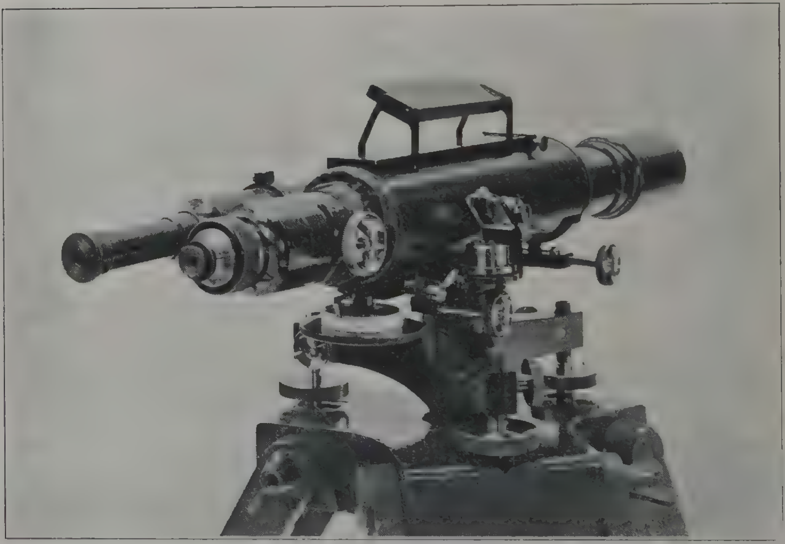

FIG. 4. — LATEST TYPE OF PRECISE LEVELING INSTRUMENT USED BY THE UNITED STATES COAST AND GEODETIC SURVEY.

A special type of rod is used. The foot-piece is a massive steel casting, with very hard bottom surface, finished flat and normal to the axis of the rod. The reading graduations are in centimeter spaces, which are read to millimeters by estimation, and are placed upon an invar strip riveted to the foot-piece and supported in a straight vertical position by the wooden backing piece, upon which the meters and decimeters are numbered. Graduations in feet on the back furnish means of taking rough check readings. The invar strip is not fastened to the wooden piece, but merely supported loosely in a groove therein. The rod is provided with a carrying handle, a small universal level for holding it plumb, and a thermometer held in contact with the invar strip.

A photograph shows two views of the bronze tablets used as bench marks. They are designed to resist extraction or turning, when grouted into a drill hole in rock or masonry or set into a concrete pier in the ground. These bench marks are numbered serially in each state, beginning at capital A and on through the alphabet, then beginning A1, B1, etc., A2, B2, etc. The designation and date are stamped upon the tablet when placed.

Procedure. — Precise leveling usually follows railroad lines, since they give the shortest distances, and are free from steep grades. All precise leveling is performed in sections, usually about one kilometer in length. Every section is leveled over in each direction. An acceptable determination of the difference of elevation of any section is reached when the forward and backward runnings give values differing by not more than 4.0 mm. $\sqrt{K}$ where K is the length of the section in kilometers. If this agreement is not reached a new pair of runnings must be made, and so until a satisfactory pair is obtained. Those runnings not differing by more than 6 millimeters from the mean of all runnings are then averaged for the section. It is a requirement, adopted in 1912 by the International Geodetic Association for leveling of high precision, that the forward and backward runnings of a section be run on different days, and at different times of the day, if possible without great expense. It is desirable to have as widely different atmospheric conditions as is possible. This will tend to cause greater differences between the two values obtained, but a mean of the two will be nearer the true value. A word is desirable here about the matter of atmospheric conditions and refraction. It may seem to the casual reader that, for leveling of great accuracy, an allowance of 4.0 mm. $\sqrt{K}$ is excessively large. It is entirely out of pro-portion to the accuracy with which the rods can be read. It is found, however, that refraction and heat wave disturbance make it entirely uneconomical to attempt to get smaller differences, especially on grades where one line of sight is nearer the ground than the other. Thus the requirement that different atmospheric conditions prevail for the different runnings is to reduce the error from this source. That we are able to do so is shown by the comparatively small closures obtained in closing circuits. Great care is taken to prevent mistakes of whole meters or decimeters, which, however, can be detected, by comparison with the "foot" readings made at the same time. A correction of an even quantity of this sort can be made in the record, without further field work, only if there are two other determinations of the section not subject to such uncertainty.

Two rods are used, and at alternate stations the foresight is taken first; at the other alternate stations the backsight first. This eliminates any error due to settling of the instrument after setting it up. Each rod will be read twice on any turning point, first as a foresight, then as a backsight from the next station ahead. This eliminates errors due to differences, if any, in the lengths of the rods.

Inasmuch as different turning points are used on the second running of any section, no transposition of backsight and foresight is ever likely to remain undetected, for if it did a transposition would of necessity have occurred in each running of the section, and would have had to involve almost exactly the same difference in elevation in each case, which is unlikely to happen.

The heads of rail spikes are commonly used as turning points. Clean, firm spikes are selected, and the rod is placed with the highest point of the spike directly under the center of the foot of the rod. This can be tested easily by turning the rod about its axis when resting in the spike, and noting whether the foot rotates about its geometric center. An attempt is made to avoid having a train run over the track while the elevation is held on a turning point, but it sometimes happens. Sufficient tests have shown, however, that a firm spike invariably returns to its former elevation, within the limit of accuracy of reading the rod. This method of selecting turning points has proven very satisfactory, more so, in fact, than the use of foot pins driven in the ground.

The stadia intervals are kept in the record, and the sum of backsight distances is kept equal to the sum of foresight distances in any section. This eliminates errors due to faulty adjustment of the level vial.

The instruments are of sturdy, simple construction, and the method of observing is simple and rapid. It takes a new observer several weeks of practice to become very proficient in the use of the precise level. An experienced observer, however, will find it possible to cover 2½ miles of distance per hour under ideal conditions, without the use of railroad motor speeders. The work can be carried on to best advantage in heavily overcast, cool weather, when the absence of heat waves in the air allows the use of the maximum permissible length of sight, 150 meters. Working without motor-speeders an experienced observer can complete from 80 to 100 miles a month of double run line under average summer conditions. The party is located in towns conveniently situated along the line, and goes to work from town by automobile. Uusually about twenty miles of line each way

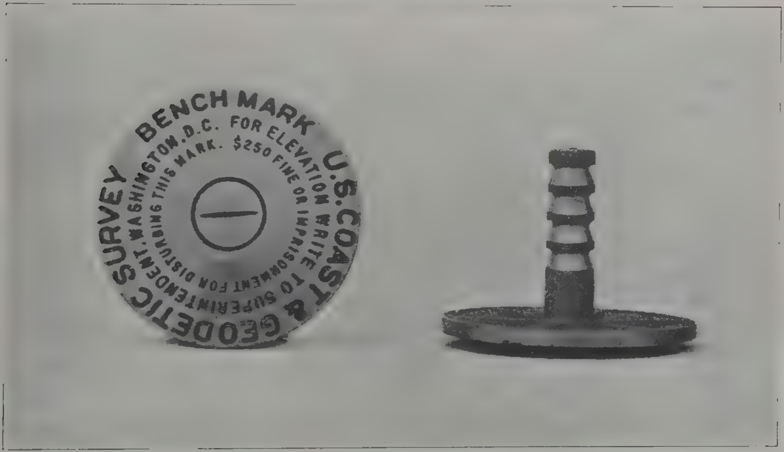
BENCH MARK
U.S. COAST & GEODETIC SURVEY
FOR ELEVATION WRITE TO SUPERINTENDENT, WASHINGTON, D.C.
$250 FINE OR IMPRISONMENT FOR DISTURBING THIS MARK.

FIG. 5. — STANDARD BENCH MARK OF UNITED STATES COAST AND GEODETIC SURVEY.

from town is completed before moving on. In the west or south, with light railroad traffic, motor-speeders are used, sometimes with the instrument mounted permanently in one car. As much as 170 miles a month have been done by a single observing party under these conditions. The party in such a case maintains its own camp, moving it when and where desirable.

The practice in the Coast and Geodetic Survey is to make the Chief of Party responsible for all details of organization and management of the party and the purchase and care of all equipment except instruments. He is also made a disbursing officer, settling accounts directly in the field.

Further Information. — Any information as to elevations not published herein, or concerning the instruments or work, will be gladly furnished upon application to the Director, United States Coast and Geodetic Survey, Washington, D. C., or to Captain D. B. Wainwright, Inspector in charge, Boston Field Office, Appraiser's Stores, Atlantic Avenue, Boston.

BENCH MARKS BETWEEN PORTLAND AND PROVIDENCE

The following matter gives the descriptions and elevations of the bench marks between Portland, Me., and Providence, R. I. Those denoted by a capital letter are the ones established by the United States Coast and Geodetic Survey. The others are bench marks of the various organizations whose levels were tied into in the course of the work.

DESCRIPTIONS AND ELEVATIONS OF PERMANENT BENCH MARKS *

Portland, Maine, to Boston, Massachusetts; Boston and Vicinity; and Providence, Rhode Island, to Boston, Massachusetts.

The elevations in the following list are the result of a line of precise levels (based on mean sea level datum) run by the United States Coast and Geodetic Survey from Portland, Me., to Boston, Mass., and from Providence, R. I., to Boston. This leveling, which forms a portion of a closed circuit in New England, is shown on a sketch map accompanying this article. The detailed route in the vicinity of Boston is shown on another diagram.

The route followed the line of the Boston & Maine Railroad from Portland to Boston and included important points such as Dover and Portsmouth, N. H., and Haverhill, Lawrence and Lowell in Massachusetts. At Boston spur lines were run to the Charlestown Navy Yard, around the Newton Circuit of the Boston & Albany Railroad and to the South Boston Dry Dock. The leveling followed the line of the New York, New Haven & Hartford Railroad from Providence, via Attleboro, to Boston.

The bench marks have been grouped in the following order:

Portland, Me., to Boston, Mass.:
    Maine.
    New Hampshire.
    Massachusetts.
Boston and Vicinity:
    Spur Line, East Cambridge to Charlestown.
    Newton Circuit.
    Spur Line, Boston to South Boston.
Providence, R. I., to Boston, Mass:
    Rhode Island.
    Massachusetts.

If it is found that any of the bench marks herein described is disturbed, or that the description is not in accordance with the facts, please notify the Director, United States Coast and Geodetic Survey, Washington, D. C.

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* Reprints of this may be obtained upon application to the Society.

PORTLAND, MAINE, TO BOSTON, MASSACHUSETTS

Bench Marks in Maine

Tidal B. M. 33. — At **Portland,** Cumberland County, at No. 79 Commercial Street, W. L. Blake & Co., Mill and Steamship Supplies, about 40 paces north of Custom House Street, on the lower stone sill, 1 foot above the sidewalk, of the doorway to the store. A 2-inch cross cut. (3.920 meters or 12.861 feet.)

L 5. — At **Portland,** Cumberland County, in the top of the lower course of the pier just southeast of Commercial Street supporting the Portland Bridge over the Fore River, connecting Breckett Street, Portland, with Knightville, between Commercial Street and the tracks connecting the Commercial Street service tracks with the water front freight yards, 16 feet from the southwest end of the pier and 4 feet above the ground. A brass disk. (4.736 meters or 15.538 feet.)

M 5. — At **Rigby,** Cumberland County, 2 rails south of the Boston & Maine Railroad depot, in the southeast quarter of a road crossing, 12 feet south of the road and 17 feet east of the east rail. A concrete post with disk in top. (11.525 meters or 37.812 feet.)

N 5. — At **Scarboro,** Cumberland County, just north of the Boston & Maine Railroad depot and 3 rails north of bridge No. 119, in the retaining wall 7 feet east of the east rail and 2 feet above the ground. A brass disk. (5.170 meters or 16.962 feet.)

O 5. — At **Pine Point,** Cumberland County, 6 rails south of the Boston & Maine Railroad depot, in a boulder 51 feet north of a highway and 129 feet east of the east rail. A brass disk. (3.925 meters or 12.877 feet.)

P 5. — At **Old Orchard,** York County, about 300 feet north of the Boston & Maine Railroad depot, in the southeast corner of the concrete building foundation of the Vermount Dairy, 54 feet west of the west rail and 1 foot above the ground. A brass disk. (3.385 meters or 11.106 feet.)

B 104. — At **Old Orchard,** York County, in the top of milepost B 104 of the Boston & Maine Railroad. A brass disk. (4.879 meters or 16.007 feet.)

Q 5. — About 1½ miles south of **Old Orchard,** York County, on the Boston & Maine Railroad, about 600 feet south of milepost B 102, 9 feet north of a private road and 39 feet west of the west rail. A concrete post with disk in top. (8.989 meters or 29.491 feet.)

R 5. — At **Saco,** York County, 9 rails south of the Boston & Maine Railroad depot, 10 feet south of semaphore D 996, on the top at the west end of the north abutment of bridge No. 107, 7 feet west of the west rail. A brass disk. (19.954 meters or 65.466 feet.)

S 5. — At **Biddeford,** York County, in ledge rock on the south bank of the Saco River, 84 feet east of the east stone retaining wall of the Biddeford Light and Heat Co., 174 feet east of the last power transmission tower on the south side of the river and 4 feet above the ground. A brass disk. (2.032 meters or 6.667 feet.)

U. S. E. — At **Biddeford,** York County, on the south side of the Saco River near the outer end of the second small rocky point east of the easterly pier of the Biddeford Light and Heat Co., 15 feet east of Bench Mark S 5. A ¾-inch hole drilled horizontally into the ledge rock at the high tide mark. (1.400 meters or 4.593 feet.)

T 5. — About 2 miles south of **Biddeford,** York County, on the Boston & Maine Railroad, about $\frac{1}{4}$ mile south of signal P 917 where the eastern and western divisions begin to diverge, in ledge rock in a rock cut, 9 feet east of the east rail and 1 foot above the ground. A brass disk. (33.259 meters or 109.117 feet.)

U 5. — About $2\frac{1}{4}$ miles north of **Arundel,** York County, on the Boston & Maine Railroad, $2\frac{1}{2}$ rails north of semaphore D 94.6 and 115 feet west of the west rail, in ledge rock on house property owned by J. H. Johnson. A brass disk. (37.096 meters or 121.706 feet.)

V 5. — At **Arundel,** York County, in the ledge rock which is a part of the foundation of the south wall of a barn opposite the Boston & Maine Railroad depot, 173 feet west of the west rail and 6 feet south of the barn wall. A brass disk. (23.830 meters or 78.182 feet.)

W 5. — At **Kennebunk,** York County, 1 rail north of the north end of the Boston & Maine Railroad depot platform, in the west abutment of bridge No. 96 on Summer Street, 4 feet west of the west rail and 1 foot above the ground. A brass disk. (15.562 meters or 51.056 feet.)

X 5. — About 2 miles north of **Wells Beach,** York County, on the Boston & Maine Railroad, about 350 feet north of milepost P 28, B 87, in the top at the east end of the north abutment of the bridge over the Kennebunk–Wells highway, 5 feet east of the east rail. A brass disk. (14.413 meters or 47.287 feet.)

Y 5. — About 1 mile north of **Wells Beach,** York County, on the Boston & Maine Railroad, in a boulder in a field directly opposite the north end of the depot at The Elms, 147 feet west of the west rail. A brass disk. (20.065 meters or 65.830 feet.)

Z 5. — About $\frac{3}{4}$ mile south of **Wells Beach,** York County, on the Boston & Maine Railroad, 11 telegraph poles south of signal D 845, 120 feet south of the Wells–Dover highway, and 420 feet west of the west rail, in the top of a large granite boulder in a field. A brass disk. (35.533 meters or 116.578 feet.)

A 6. — About $2\frac{1}{2}$ miles south of **Wells Beach,** York County, on the Boston & Maine Railroad, about 700 feet south of the Wells–North Berwick highway bridge over the railroad at Merriland Ridge, 5 rails south of signal D 818, in a large boulder 24 feet west of the west rail. A brass disk. (57.765 meters or 189.517 feet.)

B 6. — About $2\frac{1}{2}$ miles north of **North Berwick,** York County, on the Boston & Maine Railroad, 198 feet south of Sanford Road Crossing, 9 feet south of milepost P 35, B 80, in ledge rock 31 feet east of the east rail. A brass disk. (54.164 meters or 177.703 feet.)

C 6. — At **North Berwick,** York County, in a concrete pier of highway bridge No. 85 which is the first bridge north of the Boston & Maine Railroad depot, 108 feet north of the intersection of the eastern and western divisions of the railroad, 10 feet west of the west rail and $2\frac{1}{2}$ feet above the ground. A brass disk. (44.688 meters or 146.614 feet.)

D 6. — About 2 miles north of **Agamenticus,** York County, on the Boston & Maine Railroad, 32 telegraph poles south of bridge No. 84, 16 telegraph poles south of milepost P 36, B 72, in a rock cut, 90 feet from its north end and 36 feet from its south end, in ledge rock 9 feet west of the west rail and 1 foot above the ground. A brass disk. (44.470 meters or 145.899 feet.)

E 6. — At **Agamenticus**, York County, $3\frac{1}{4}$ rails north of the Boston & Maine Railroad depot, in the top at the south end of the west abutment of a highway bridge over a stream, 75 feet east of the east rail. A brass disk. (28.848 meters or 94.646 feet.)

F 6. — At **Jewett**, York County, about 350 feet south of the south end of the Boston & Maine Railroad depot platform, 600 feet south of the south end of the depot, in ledge rock 3 feet west of the west rail and 1 foot above the ground. A brass disk. (29.491 meters or 96.755 feet.)

U. S. G. S. — At **South Berwick,** York County, in the top of milepost I 71 near the Boston & Maine Railroad depot. A brass disk marked " 101.7 feet." (30.937 meters or 101.499 feet.)

Bench Marks in New Hampshire

U 1. — At **Salmon Falls,** Strafford County, about 300 feet north of the Boston & Maine Railroad, in the top at the west end of the south abutment of the inter-state railroad bridge over the Salmon Falls River, 7 feet west of the west rail. A brass disk. (32.157 meters or 105.502 feet.)

V 1. — About $1\frac{3}{4}$ miles north of **Dover,** Strafford County, on the Boston & Maine Railroad, about 350 feet south of signal D 685, in a rock ledge 8 feet west of the west rail and 2 feet above the track. A brass disk. (35.246 meters or 115.636 feet.)

W 1. — At **Dover**, Strafford County, 1 block north of the Boston & Maine Railroad depot, in the top at the west end of the south abutment of the bridge over Broadway Street, 14 feet west of the west rail. A brass disk. (23.018 meters or 75.518 feet.)

Y 1. — At **Dover**, Strafford County, in the foundation course on the south wall of the post office building, 5 feet east of the entrance and 16 inches above the ground. A brass disk. (17.229 meters or 56.525 feet.)

Z 1. — About 3 miles east of **Dover,** Strafford County, on the Boston & Maine Railroad in a sandy plot in line with the telegraph poles, 93 feet north of the east end of the depot at Cushings, 75 feet north of the north rail and 5 feet south of a fence. A concrete post with disk in top. (11.134 meters or 36.529 feet.)

Tidal B. M. 1. — At **Dover Point,** Strafford County, about 6 inches below high water mark due south of the Dover Point Hotel, 6 feet from the northeasterly one of two willow trees just above high water mark, 60 feet north of the intersection of high water mark with the pier on the southeast side of the point. A copper bolt cemented in the rock, lettered "USC&GS, 1913." (0.916 meters or 3.005 feet.)

Tidal B. M. 2. — At **Dover Point,** Strafford County, on the shore line north of the Dover Point Hotel, in the only rocky ledge in sight about 600 feet to the northwest of the tidestaff. A copper bolt cemented in the rock. (2.206 meters or 7.238 feet.)

A 2. — About 2 miles west of **Portsmouth,** Rockingham County, on the Boston & Maine Railroad, about 700 feet west of the depot at Piscataqua, $4\frac{3}{4}$ rails west of the switch block at the west end of the freight tracks, in a boulder 10 feet south of the south rail. A brass disk. (7.792 meters or 25.564 feet.)

Tidal B. M. 1. — Near **Portsmouth,** Rockingham County, in the Atlantic Corporation Shipyard on the Piscataqua River, in the east face near the northeast corner of the concrete foundation of brick building No. 2, near the southeast corner of the plate shop. A brass disk. (8.372 meters or 27.467 feet.)

Tidal B. M. 2. — Near **Portsmouth,** Rockingham County, in the Atlantic Corporation Shipyard on the Piscataqua River, on top of the circular granite curbing of a well about 30 feet northwest of a white cottage on the bluff west of the old wharf, which is just north of the shipways. A brass disk. (12.601 meters or 41.342 feet.)

Tidal B. M. 3. — Near **Portsmouth,** Rockingham County, in the Atlantic Corporation Shipyard on the Piscataqua River, at the foot of the bluff west of the old wharf which is just north of the shipways, 15 feet north of a break in the bluff through which a road leads to the northward of a white cottage, in a small smooth ledge of rock projecting a little above the ground. A brass disk. (4.821 meters or 15.817 feet.)

U. S. G. S. — At **Portsmouth,** Rockingham County, on the north side of the Federal Building or Custom House, in the granite window-seat of the second window from Court Street. A metal plate stamped "30 Concord." (9.126 meters or 29.941 feet.)

B 2. — At **Portsmouth,** Rockingham County, about 450 feet north of the Boston & Maine Railroad depot, 300 feet south of milepost B 57, P 51, in ledge rock 5 feet above the track and 8 feet east of the east rail, opposite the Littlefield Lumber Co. A brass disk. (6.190 meters or 20.308 feet.)

C 2. — About 1¾ miles south of **Portsmouth,** Rockingham County, on the Boston & Maine Railroad, about 250 feet south of milepost P 53, B 55, in the west abutment of bridge No. 66, 4 feet west of the west rail and 1½ feet above the track. A brass disk. (16.371 meters or 53.711 feet.)

D 2. — About ⅓ mile north of **Breakfast Hill,** Rockingham County, on the Boston & Maine Railroad, about 700 feet south of milepost P 56, B 52, 16 telegraph poles north of bridge No. A65, in the top of ledge rock in a wooded lot 50 feet east of the east rail. A brass disk. (18.401 meters or 60.371 feet.)

E 2. — About ⅛ mile north of **Hampton,** Rockingham County, on the Boston & Maine Railroad, about 700 feet north of milepost P 59, B 49, in the side of a large boulder in a field, 500 feet west of the west rail and 2 feet above the ground. A brass disk. (18.724 meters or 61.430 feet.)

F 2. — At **Hampton,** Rockingham County, in the bottom course at the north end of the west abutment of the Boston & Maine Railroad bridge just north of the depot, 6 feet west of the west rail. A brass disk. (17.011 meters or 55.810 feet.)

G 2. — About 2 miles south of **Hampton,** Rockingham County, on the Boston & Maine Railroad, 81 feet north of the north end of the depot at Hampton Falls, 39 feet south of an elevated tool house, 50 feet west of the west rail and 8 feet east of a fence. A concrete post with disk in top. (2.543 meters or 8.343 feet.)

H 2. — At **Atlantic,** Rockingham County, about 700 feet south of the Boston & Maine Railroad depot, about 450 feet south of bridge No. 54, 250 feet south of signal 415, in the rock wall of a cut 12 feet east of the east rail. A brass disk. (17.553 meters or 57.588 feet.)

Bench Marks in Massachusetts

Y. — At **Salisbury,** Essex County, about ⅛ mile south of the Boston & Maine Railroad depot, in the west abutment of bridge No. 52, at the track level 15 feet north of the south end of the abutment and 7 feet west of the west rail. A brass disk. (4.302 meters or 14.114 feet.)

A 1. — About ½ mile south of **Salisbury,** Essex County, on the Boston & Maine Railroad, about 200 feet south of milepost B 38, P 70, in ledge rock 55 feet east of the east rail. A brass disk. (6.081 meters or 19.951 feet.)

B 1. — At **Newburyport,** Essex County, in the top at the west end of the south abutment of the bridge which begins at the north end of the Boston & Maine Railroad depot platform, 15 feet west of the west rail. A brass disk. (10.406 meters or 34.140 feet.)

F 1. — At **Newburyport,** Essex County, in the south wall, near the southwest corner, of the Newburyport Police Court Building on Green Street, 2½ feet above the ground. A brass disk. (8.113 meters or 26.617 feet.)

Z. — About 3 miles southwest of **Newburyport,** Essex County, on the Boston & Maine Railroad, 1½ rails west of a private road crossing, 2 rails west of culvert No. 168 O, in rock outcrop in a pasture 57 feet south of the south rail and 3 feet above the ground. A brass disk. (13.282 meters or 43.576 feet.)

C 1. — At **Byfield,** Essex County, about 700 feet east of the Boston & Maine Railroad depot, 350 feet east of the most easterly road crossing in town, in the top of a large boulder 12 feet north of the north rail and 3½ feet above the track. A brass disk. (20.014 meters or 65.663 feet.)

D 1. — About ½ mile northeast of **Georgetown,** Essex County, 8 telegraph poles east of the east end of the Boston & Maine Railroad yards, in the top at the south end of the west abutment of culvert No. 166, 12 feet south of the south rail. A brass disk. (22.642 meters or 74.285 feet.)

E 1. — About 1 mile northwest of **Georgetown,** Essex County, and 1 mile southeast of Groveland, 550 feet west of King Street Crossing, in the top of a large boulder 20 feet south of the south rail. A brass disk. (29.298 meters or 96.122 feet.)

G 1. — About 2 miles southeast of **Bradford,** Essex County, 350 feet south of the Boston & Maine Railroad depot at Island Park, in the north end of a stone at the north end of an old building foundation, 21 feet west of a circular brick pit, and 12 feet east of the east rail. A brass disk. (6.629 meters or 21.749 feet.)

U. S. E. 107. — At **Bradford,** Essex County, about ½ mile east of the Boston & Maine Railroad depot, 900 feet west of the bridge crossing the Merrimack River and the railroad, and 3 feet north of the north rail, in a 6-inch square granite post projecting 6 inches above the ground. A brass rod extending 2 inches from the post. (7.962 meters or 26.122 feet.)

H 1. — At **Bradford,** Essex County, about 200 feet east of the east end of the Boston & Maine Railroad depot platform, 1 rail west of bridge No. A 34, in the top of a boulder 23 feet west of the west rail. A brass disk. (11.553 meters or 37.903 feet.)

N 1. — At **Haverhill,** Essex County, at the south end of the Boston & Maine Railroad depot, in the top of a granite block in the center of the north abutment of the bridge over Washington Street, 6 feet north of the yard signal set on the bridge structure and 4 feet west of the west rail. A brass disk. (15.374 meters or 50.440 feet.)

J 1. — About ½ mile southwest of **Ward Hill,** Essex County, on the Boston & Maine Railroad, 450 feet east of signal D 301, in ledge rock in the side of a cut, 2 feet above the ground. A brass disk. (16.987 meters or 55.732 feet.)

K 1. — About ¼ mile west of **North Andover,** Essex County, on the Boston & Maine Railroad, in the top at the south end of the west abutment of the Merrimack Street bridge over a canal, connecting Lawrence and North Andover. A brass disk. (10.750 meters or 35.269 feet.)

L 1. — At **South Lawrence,** Essex County, in an angle formed by the Boston & Maine Railroad depot structures, in the southeast corner of a small triangular park enclosed by an iron fence, about 3 feet from the fence. A concrete post with disk in top. (18.619 meters or 61.086 feet.)

M 1. — At **West Andover,** Essex County, 4¼ rails south of the Boston & Maine Railroad bridge No. 300 which is the second bridge south of the depot, in a boulder 12 feet east of the east rail. A brass disk. (46.806 meters or 153.563 feet.)

O 1. — About ¼ mile south of **Haggett,** Essex County, on the Boston & Maine Railroad, 450 feet south of Flint's Crossing which is the second crossing south of the depot, in ledge rock in a cut, 6 feet west of the west rail. A brass disk. (37.297 meters or 122.365 feet.)

P 1. — About ½ mile east of **Tewksbury,** Middlesex County, on the Boston & Maine Railroad, in the bottom stone in the center of the east abutment of the bridge carrying the Lowell–Lowell Junction line over the Lowell–Lawrence line, 25 feet east of the east rail. A brass disk. (30.975 meters or 101.624 feet.)

Q 1. — At **Wamesit,** Middlesex County, directly opposite the Boston & Maine Railroad depot, in ledge rock in the southeast quarter of the main highway crossing, 3 feet east of a fence and 27 feet south of the south rail. A brass disk. (41.692 meters or 136.784 feet.)

R 1. — About ¾ mile south of **Lowell,** Middlesex County, just north of the Boston & Maine Railroad depot at Bleachery, in the top at the west end of the north abutment of the bridge over Gorham Street, 4 feet west of the west rail. A brass disk. (34.508 meters or 113.215 feet.)

T 1. — At **Lowell,** Middlesex County, on the west side of the Boston & Maine Railroad track and opposite the depot, in the side of the stone retaining wall, 27 feet south of its north end and 6 inches above the ground. A brass disk. (30.534 meters or 100.177 feet.)

Lowell City B. M. — At **Lowell,** Middlesex County, in the east doorway on the north side of the Boston & Maine Railroad depot. The outer west corner of the step. (31.110 meters or 102.067 feet.)

Locks and Canals Corporation B. M. — At **Lowell,** Middlesex County, on the south abutment of the bridge pier over the canal north of the Boston & Maine Railroad depot. A copper-headed bolt in the masonry. (27.480 meters or 90.157 feet.)

U 1. — At **South Lowell,** Middlesex County, about 300 feet north of the north end of the Boston & Maine Railroad depot, in the top of ledge rock 11 feet east of the east rail and 2 feet above the ground. A brass disk. (36.793 meters or 120.712 feet.)

S 1. — At **North Billerica,** Middlesex County, about 400 feet north of the Boston & Maine Railroad depot, in the top of a boulder halfway between two trees, on the fence line 32 feet east of the east rail. A brass disk. (38.705 meters or 126.985 feet.)

V 1. — At **East Billerica,** Middlesex County, 4 rails north of the Boston & Maine Railroad depot, in the side of the west abutment of bridge No. 46, 9 feet west of the west rail and 4 inches above the ground. A brass disk. (33.586 meters or 110.190 feet.)

W 1. — About $\frac{1}{2}$ mile northwest of **Silver Lake,** Middlesex County, on the Boston & Maine Railroad, 450 feet south of bridge No. 39, 2 rails south of milepost B 17, C 57, in a boulder 30 feet east of the east rail. A brass disk. (32.207 meters or 105.666 feet.)

Y 1. — At **Wilmington,** Middlesex County, at the south end of the west abutment of the Boston & Maine Railroad bridge south of the depot, in the top of the end stone in the second tier. A brass disk. (29.158 meters or 95.662 feet.)

X 1. — About 1 mile southeast of **Wilmington,** Middlesex County, on the Boston & Maine Railroad, about 500 feet north of milepost B 14, C 64, $3\frac{1}{2}$ rails south of bridge No. 34, in the wall of a rock cut, 2 feet above the ground and 8 feet west of the west rail. A brass disk. (25.310 meters or 83.038 feet.)

Z 1. — About $3\frac{1}{2}$ miles southeast of **Wilmington,** Middlesex County, on the Boston & Maine Railroad, 1 rail south of the depot at Mishawum, in the top at the north end of the east pier of bridge No. 30, 4 feet east of the east rail. A brass disk. (18.172 meters or 59.619 feet.)

A 2. — About 1 mile north of **Winchester,** Middlesex County, $\frac{1}{8}$ mile north of the Boston & Maine Railroad depot at Winchester Highlands, 550 feet south of signal No. 93, in the side of a large boulder, slightly above track level and 147 feet west of the west rail. A brass disk. (11.726 meters or 38.471 feet.)

B 2. — At **Winchester,** Middlesex County, in the north face near the northwest corner of the Winchester Town Hall, west of the west entrance and 3 feet above the ground. A brass disk. (9.102 meters or 29.862 feet.)

C 2. — At **Medford,** Middlesex County, in the rear of the house at 56 Orchard Street, about 550 feet south of bridge No. 20, 5 rails north of signal No. 4.7, in the top of a boulder 36 feet east of the east rail. A brass disk. (8.523 meters or 27.963 feet.)

Boston & Maine Railroad B. M. "A". — At **North Somerville,** Middlesex County, on the east abutment near the north end of the Boston & Maine Railroad overhead bridge south of the depot. A point on the masonry. (11.077 meters or 36.342 feet.)

Boston & Maine Railroad B. M. "B". — At **Somerville Junction,** Middlesex County, on the southeast corner of the concrete base of the Boston & Maine Railroad block signal No. 30. A point on the masonry. (10.812 meters or 35.472 feet.)

D 2. — At **Somerville Junction,** Middlesex County, in the rock wall of a cut 40 feet south of the Boston & Maine Railroad bridge No. 12, which is the second bridge south of the depot, and 12 feet east of the east rail. A brass disk. (10.030 meters or 32.907 feet.)

E 2. — At **East Cambridge,** Middlesex County, about 600 feet north of the Boston & Maine Railroad depot, in the top of the footing at the east end of the north abutment of the bridge carrying the Southern Division over the Fitchburg Division, 4 feet east of the east rail and 2 feet above the Fitchburg Division track level. A brass disk. (2.792 meters or 9.160 feet.)

BOSTON AND VICINITY

Spur Line, East Cambridge to Charlestown

F 2. — Near **Charlestown,** Suffolk County, vertically in the center of the west side of the fourth pier from the eastern or Charlestown end of the "Prison Point Bridge," which is a viaduct carrying Prison Point Street over the railroad tracks and connecting East Cambridge and Charlestown. A brass disk. (3.528 meters or 11.575 feet.)

Boston City B. M. — At **Charlestown,** Suffolk County, on the right outer corner, facing the building, of the second stone step at the entrance to Waverley House on the City Square. A point on the step. (5.529 meters or 18.140 feet.)

Tidal B. M. 1. — At **Charlestown,** Suffolk County, at the entrance to the old dry dock in the Charlestown Navy Yard, on the top of the granite wall directly over the inlaid bronze scale at the southwest corner and outside the floating gate of the dock. As part of the rock was chipped off the nearest place on the outer edge of the coping was used, 1 or 2 inches from the center of the scale. (2.993 meters or 9.820 feet.)

Tidal B. M. 2 (Navy Yard B. M. 1). — At **Charlestown,** Suffolk County, on the west side and near the head of the old dry dock, directly over the foot of the long steps, indicated by an arrow cut in the side of the stone. The top of the facing as indicated by the arrow. (2.882 meters or 9.455 feet.) This bench mark is the basic bench mark for the Boston City levels.

Tidal B. M. 3. — At **Charlestown,** Suffolk County, in the granite block at the head of Dry Dock No. 2 in the Charlestown Navy Yard. A brass disk. (2.730 meters or 8.957 feet.)

Navy Yard B. M. 8. — At **Charlestown,** Suffolk County, at the head of Dry Dock No. 2 in the Charlestown Navy Yard in the top of the masonry about 1 foot north of Tidal B. M. No. 3. A chiseled square. (2.891 meters or 9.485 feet.)

Navy Yard B. M. 10. — At **Charlestown,** Suffolk County, north of the tennis courts in the Charlestown Navy Yard, in the pier supporting a column on the southeast side of an octagonal building. A chiseled square. (4.056 meters or 13.307 feet.)

Navy Yard B. M. 18. — At **Charlestown,** Suffolk County, in the Charlestown Navy Yard, at the corner of Second Avenue and Thirteenth Street, in the top of the lower course of masonry at the southwest corner of Building 75. A chiseled square. (3.336 meters or 10.945 feet.)

Navy Yard B. M. 19. — At **Charlestown,** Suffolk County, in the Charlestown Navy Yard, at the corner of Fifth Avenue and Sixteenth Street, in the top of the lower course of stone at the northeast corner of Building 77. A chiseled square. (3.956 meters or 12.979 feet.)

(*End of spur line*)

Massachusetts Institute of Technology B. M. — At **Cambridge,** Middlesex County, in the basement of the Massachusetts Institute of Technology, in the floor in front of the door to room 3–019, in the concrete cap on a pile driven into the ground and covered by an iron plate in the floor. A brass plug in the concrete cap. (1.586 meters or 5.203 feet.)

Cambridge City B. M. — At **Cambridge,** Middlesex County, in the top at the west end of the north abutment of Harvard Bridge carrying Massachusetts Avenue over the Charles River, at the street level and on the Charles River Road, 2 feet from the railings on the bridge. A brass plug. (4.557 meters or 14.951 feet.)

G 2. — At **Boston,** Suffolk County, at the east end of the center support of Cottage Farm Bridge No. 18 carrying Commonwealth Avenue over the Boston & Albany Railroad tracks at mileage 3.13, in the east face of the support 2½ feet above the ground. A brass disk. (3.353 meters or 11.001 feet.)

Newton Circuit

Van Orden Cottage Farm B. M. — At **Boston,** Suffolk County, at the east end of the foundation of the north abutment of Cottage Farm Bridge No. 18 carrying Commonwealth Avenue over the Boston & Albany Railroad tracks at mileage 3.13. A chiseled square. (3.071 meters or 10.075 feet.)

Boston & Albany Cottage Farm B. M. — At **Boston,** Suffolk County, on the west wing, south abutment, of Cottage Farm Bridge No. 18 carrying Commonwealth Avenue over the Boston & Albany Railroad tracks at mileage 3.13, in the northwest corner of the lower coping stone. A chiseled square. (3.809 meters or 12.497 feet.)

Cottage Farm Boston City B. M. — At **Boston,** Suffolk County, in line with the north curb of Commonwealth Avenue and southwest of the Boston & Albany Railroad tracks, near the northwest end of the top of the abutment of Cottage Farm Bridge No. 18 carrying Commonwealth Avenue over the railroad at mileage 3.13. A point on the bridge abutment. (8.474 meters or 27.802 feet.)

Boston & Albany Allston B. M. — At **Boston,** Suffolk County, on the west door to the waiting room of the Boston & Albany Railroad depot at Allston, on the northwest corner of the door sill. A chiseled square. (8.141 meters or 26.709 feet.)

K 2. — At **Boston,** Suffolk County, about ¼ mile west of the Boston & Albany Railroad depot at Faneuil, 450 feet west of milepost B 6, in the top of a large boulder 180 feet south of the south rail. A brass disk. (10.148 meters or 33.294 feet.)

Boston & Albany Newton B. M. — At **Newton,** Middlesex County, on the northeast corner of the basement door sill of the Boston & Albany Railroad depot. A chiseled square. (10.210 meters or 33.497 feet.)

L 2. — At **Newtonville,** Middlesex County, about 200 feet west of the Boston & Albany Railroad depot, in the north abutment of bridge No. 8.20, 18 feet from the east end, 10 feet north of the north rail, and 6 inches above the track. A brass disk. (13.762 meters or 45.151 feet.)

Boston & Albany B. M. — Near **Newtonville,** Middlesex County, on the Boston & Albany Railroad bridge No. 25 B at mileage 8.57, on the corner of the east stone in the first course of the south abutment. A chiseled square. (14.719 meters or 48.291 feet.)

Boston & Albany Auburndale B. M. — At **Auburndale,** Middlesex County, on the northwest corner of the door sill of the baggage room at the Boston & Albany Railroad depot. A chiseled square. (20.363 meters or 66.808 feet.)

M 2. — About 1 mile southwest of **Auburndale,** Middlesex County, on the Boston & Albany Railroad, in the top of the coping at the north end of the foot-subway under the tracks at the Riverside depot, 15 feet west of signal bridge No. 10.87 and 8 feet north of the north rail. A brass disk. (21.656 meters or 71.050 feet.)

N 2. — At **Woodland,** Middlesex County, about 1,000 feet south of the south end of the Boston & Albany Railroad depot, in the top of a large boulder on the hillside 34 feet east of the east rail and 450 feet south of the south end of the Boston & Albany Railroad bridge No. 9. A brass disk. (32.235 meters or 105.758 feet.)

O 2. — At **Newton Center,** Middlesex County, about 300 feet east of the east end of the Boston & Albany Railroad depot, 9 feet north of the north rail, in the west end of the north abutment of the Boston & Albany Railroad bridge No. 5.62. A brass disk. (43.466 meters or 142.605 feet.)

P 2. — At **Boston**, Suffolk County, about ½ mile northeast of Chestnut Hill, Middlesex County, in the rock wall of a cut 2¼ rails northeast of milepost B 6, 7 feet north of the north rail, 1½ feet above the ground, and 2¾ rails southwest of the west end of the Boston & Albany Railroad bridge No. 3.71. A brass disk. (42.236 meters or 138.569 feet.)

Q 2. — At **Brookline**, Norfolk County, about 300 feet west of the west end of the Boston & Albany Railroad depot at Brookline, 5 feet south of the south rail, in the center of the south abutment of the Boston & Albany Railroad bridge No. 1.56, 3 feet above the ground. A brass disk. (5.408 meters or 17.743 feet.)

(*End of Newton Circuit*)

Van Orden St. Marys Street B. M. — At **Brookline,** Norfolk County, at the east end of the north abutment of St. Marys Street Bridge over the Boston & Albany Railroad tracks, in the top of the second stone. A chiseled square. (3.568 meters or 11.706 feet.)

Boston & Albany B. M. — At **Boston,** Suffolk County, on the northwest corner of the southwest pier of the Boston & Albany Railroad signal bridge just east of bridge No. 16 at mileage 2.41. A chiseled square. (3.480 meters or 11.417 feet.)

Boston & Albany Huntington Avenue B. M. — At **Boston,** Suffolk County, at mileage 1.35 on the Boston & Albany Railroad, on the northwest corner of the lower stone step at the baggage room door of the Huntington Avenue depot. A chiseled square. (1.378 meters or 4.521 feet.)

H 2. — At **Boston,** Suffolk County, set horizontally in the footing at the south end of the east center pier of the Boston & Albany Railroad bridge at mileage 1.19, which is the second overhead bridge south of the Trinity Place depot of the Boston & Albany Railroad. A brass disk. (0.418 meters or 1.371 feet.)

Spur Line, Boston to South Boston

Boston & Albany B. M. — At **Boston,** Suffolk County, on the northeast corner of the central pier of the Boston & Albany Railroad bridge No. 3 at mileage 0.61. A chiseled square. (0.470 meters or 1.542 feet.)

Boston & Albany B. M. (**New York, New Haven & Hartford B. M.**). — At **Boston,** Suffolk County, on the northwest corner of the end cap stone of the retaining wall at mileage 0.40 on the Boston & Albany Railroad and also on the New York, New Haven & Hartford Railroad, south of the tracks of the latter railroad. A chiseled square. (3.695 meters or 12.123 feet.)

J 2. — At **Boston,** Suffolk County, 306 feet south of the south end of the train shed at the Southern Union Station, 213 feet south of signal bridge No. 1, 63 feet north of signal bridge No. 5, 4½ feet east of an easterly approach track, in the top of the stone coping at the south end of the iron railing. A brass disk. (5.885 meters or 19.308 feet.)

Boston City B. M. — At **Boston,** Suffolk County, on the lower iron step at 83 South Street. The left outer corner of the step, facing the building. (3.897 meters or 12.785 feet.)

Weather Bureau B. M. — At **Boston,** Suffolk County, on the post office building at the corner of Milk Street and Post Office Square, in the cornerstone at the southeast corner, 1 foot above the sidewalk. A chiseled square. (4.446 meters or 14.587 feet.)

Tidal B. M. 7. — At **South Boston,** Suffolk County, on the side of the heating plant opposite Commonwealth Pier No. 5, in the upper surface of the water table. A brass disk. (4.055 meters or 13.304 feet.)

Tidal B. M. 8. — At **South Boston,** Suffolk County, in the stone retaining wall opposite the stairway leading down from Summer Street to "C" Street, on the ledge just above the first landing, about 7 feet below the top of the wall. A brass disk. (7.563 meters or 24.813 feet.)

Boston City B. M. — At **South Boston,** Suffolk County, on the granite door step at 481 Summer Street. The outer right-hand corner of the step, facing the building. (6.559 meters or 21.519 feet.)

B. M. "Dry Dock." — At **South Boston,** Suffolk County, at the southern wall of the Navy Dry Dock, on the top of a 2-inch iron rod which extends down to bed rock through the concrete backing to the wall and is enclosed in a 4-inch iron pipe with a cover marked "Bench Mark — Do not disturb." The top of the brass cap on the rod. (3.131 meters or 10.272 feet.)

Tidal B. M. 9. — At **South Boston,** Suffolk County, on the "F" Street side of No. 416 West Broadway, occupied in 1922 by P. F. Carey Furniture Co., in the water table under the third window, which is 51½ feet from the front of the building. A brass disk. (14.472 meters or 47.480 feet.)

Tidal B. M. 10. — At **South Boston,** Suffolk County, on the "F" Street side of No. 423 West Broadway, occupied in 1922 by F. W. Woolworth & Co., in the water table 2 inches above the sidewalk and 45.6 feet from the front of the building. A brass disk. (13.617 meters or 44.675 feet.)

Boston City B. M. — At **South Boston,** Suffolk County, on the right buttress of the stone stairway at No. 481 East Broadway. The right outer corner of the buttress, facing the building. (18.029 meters or 59.150 feet.)

Tidal B. M. 11. — At **South Boston,** Suffolk County, at the entrance to the Washington Monument in Thomas Park, Dorchester Heights, at the north end of the fifth marble step inside the iron gate and back of the north gate post. A brass disk. (43.856 meters or 143.884 feet.)

Tidal B. M. 12. — At **South Boston,** Suffolk County, at the north entrance to the South Boston High School, in the top of the step at the right of the doorway on entering the building. A brass disk. (34.009 meters or 111.578 feet.)

(End of spur line)

PROVIDENCE, RHODE ISLAND, TO BOSTON, MASSACHUSETTS

Bench Marks in Rhode Island

C 2. — At **Providence,** Providence County, 18 feet north of the New York, New Haven & Hartford Railroad Depot at Dike Street, at the corner of the railroad boundary fence 22 feet west of the west rail of the main line. A concrete post with disk in top. (8.924 meters or 29.278 feet.)

D 2. — At **Providence,** Providence County, on the front face of the New York, New Haven & Hartford Railroad depot, 75 feet east of the main entrance to the trains and 2½ feet above the ground. A brass disk. (7.420 meters or 24.344 feet.)

E 2. — At **Providence,** Providence County, just north of the main steps on the west side of the post office building, in the top of the balustrade 3½ feet above the sidewalk. A brass disk. (4.709 meters or 15.449 feet.)

Providence City B. M. 420. — At **Providence,** Providence County, at the east entrance steps to former Brown University Library on the north side of Waterman Street 81.70 feet east of Prospect Street, on the south end at the top of the east steps. The southeast corner of the top of the granite buttress. (40.369 meters or 132.444 feet.)

F 2. — About 2 miles north of **Providence,** Providence County, on the New York, New Haven & Hartford Railroad, 8 telegraph poles south of bridge No. 2.00 and 15 feet west of the boundary fence between the street and the railroad property. A concrete post with disk in top. (13.407 meters or 43.986 feet.)

G 2. — At **Pawtucket,** Providence County, 9½ rails south of the south end of the New York, New Haven & Hartford Railroad depot platform, in ledge rock 12 feet east of the east rail, 3 feet above the ground. A brass disk. (22.323 meters or 73.238 feet.)

K 2. — About ½ mile north of **Pawtucket,** Providence County, 8 rails north of interlocking tower No. 156 at the junction of the Worcester and the Boston Branches of the New York, New Haven & Hartford Railroad, 16 rails south of culvert No. 38.60, in a rock cut 13 feet west of the west rail and 3½ feet above the track. A brass disk. (21.565 meters or 70.751 feet.)

Bench Marks in Massachusetts

H 2. — About ¾ mile south of **Hebronville,** Bristol County, about 900 feet southwest of milepost B 36, ¼ mile northeast of Cottage Street Bridge, on the southeast end of a culvert, 18 feet east of the east rail. A brass disk. (25.890 meters or 84.941 feet.)

U 2. — At **Hebronville,** Bristol County, 2 inches below the sidewalk in front of Hebronville Fire Hall, 9 feet north of the north wall and 9 feet east of the east wall. A concrete post with disk in top. (31.890 meters or 104.626 feet.)

E. — At **Dodgeville,** Bristol County, 18 rails south of the New York, New Haven & Hartford Railroad depot, in a large boulder 16 feet west of the west rail and 4½ feet above the ground. A brass disk. (34.548 meters or 113.346 feet.)

T 2. — At **Dodgeville,** Bristol County, in front of the Dodgeville Public School, 3 inches below the sidewalk about 20 feet south of the main gate, 3 feet west of the curb. A concrete post with disk in top. (36.862 meters or 120.938 feet.)

V 2. — At **Attleboro,** Bristol County, at the northeast corner of the intersection of Turner and Washington Streets, flush with the sidewalk 4 inches from the curb line on Washington Street, 8 feet from Turner Street. A concrete post with disk in top. (29.364 meters or 96.338 feet.)

F. — At **Attleboro,** Bristol County, 7¾ rails south of the New York, New Haven & Hartford Railroad bridge No. 31.96 and the south end of the depot platform, in rock outcrop 27 feet west of the west rail. A brass disk. (39.692 meters or 130.223 feet.)

G. — At **Attleboro,** Bristol County, on the top of the east coping wall of the New York, New Haven & Hartford Railroad bridge No. 31.71 over Union Street, 12 feet south of the north end of the bridge and 12 feet east of the east rail. A brass disk. (43.682 meters or 143.313 feet.)

L. — At **Attleboro,** Bristol County, 2 inches below the sidewalk at the southeast corner of Pleasant and Lindsey Streets, 6 feet from Pleasant Street and 3 feet from Lindsey Street. A concrete post with disk in top. (39.115 meters or 128.330 feet.)

S 2. — At **Attleboro,** Bristol County, 3 inches above the ground in the northeast corner of the City Hall site, 2 feet west of the Public Library property line and 1 foot from the sidewalk. A concrete post with disk in top. (40.698 meters or 133.523 feet.)

H. — About 1 mile south of **West Mansfield,** Bristol County, on the New York, New Haven & Hartford Railroad, 23 telegraph poles south of bridge No. 28.60 at Gilbert Street, in a flat boulder 34 feet east of the east rail and 4 feet east of the railroad fence. A brass disk. (44.073 meters or 144.596 feet.)

J. — About ½ mile north of **West Mansfield,** Bristol County, on the New York, New Haven & Hartford Railroad, on the east end of the north abutment of culvert No. 27.12, 6 feet east of the east rail. A brass disk. (43.974 meters or 144.271 feet.)

Q. — At **Mansfield,** Bristol County, at the Town Hall on the corner of West and Union Streets, 29 inches north of the north wall and 25 feet west of the east wall, 19¼ feet south of West Street, and 36 feet west of Union Street. A concrete post with disk in top. (46.144 meters or 151.391 feet.)

K. — At **Mansfield,** Bristol County, 54 feet south of the road crossing at the New York, New Haven & Hartford Railroad depot, on the top at the west end of the south abutment of culvert No. 24.95, 21 feet west of the west rail. A brass disk. (50.729 meters or 166.433 feet.)

M. — At **East Foxborough,** Norfolk County, 40 rails north of the road crossing at the New York, New Haven & Hartford Railroad depot, 19 rails north of milepost 22, in ledge rock about 180 feet west of the west rail and 8 feet east of a boulder on the ledge. A brass disk. (68.306 meters or 224.101 feet.)

N. — About ¼ mile north of **Sharon Heights,** Norfolk County, on the New York, New Haven & Hartford Railroad, at the south end of the west abutment wall of the first overhead highway bridge north of the depot, 5 feet west of the west rail and 2 feet above the ground. A brass disk. (78.886 meters or 258.812 feet.)

O. — About 1 mile north of **Sharon,** Norfolk County, on the New York, New Haven & Hartford Railroad, 23½ rails north of milepost B 17 and 8½ rails north of bridge No. 25, in ledge rock 9 feet east of the east rail. A brass disk. (58.329 meters or 191.368 feet.)

P. — About ¼ mile north of **Canton Junction,** Norfolk County, on the New York, New Haven & Hartford Railroad, in a rock cut 4¾ rails north of bridge No. 14.76 at Chapman Street, 8 feet east of the east rail and 1½ feet above the ground. A brass disk. (28.759 meters or 94.353 feet.)

R. — At **Dedham Road,** Norfolk County, 13½ rails north of the New York, New Haven & Hartford Railroad depot, 10 rails north of milepost B 12, on the east end of the south abutment of bridge No. 12.77, 9 feet east of the east rail. A brass disk. (14.762 meters or 48.432 feet.)

S. — At **Readville,** Suffolk County, 7 rails north of the north end of the New York, New Haven & Hartford Railroad depot, and 153 feet east of the east rail, near the ornamental shrubbery beds at the depot. A concrete post with disk in top. (17.585 meters or 57.693 feet.)

T. — At **Hyde Park,** Suffolk County, 7½ rails north of the New York, New Haven & Hartford Railroad depot, 4 rails north of Hyde Park Bridge, in the retaining wall 13 feet west of the west rail and 2 feet above the ground. A brass disk. (15.332 meters or 50.302 feet.)

U. — At **Hyde Park,** Suffolk County, on the south side of the steps at the northwest or Central Avenue entrance to the Hyde Park Municipal Building, in a slab 3 feet above the ground. A brass disk. (23.408 meters or 76.798 feet.)

V. — At **Mount Hope,** Suffolk County, in the retaining wall bordering on Florence Street southwest of the New York, New Haven & Hartford Railroad depot, 15 iron fence posts north of the steps, 24 fence posts south of the north end of the wall, 114 feet west of the west rail and 2 feet above the ground. A brass disk. (13.297 meters or 43.625 feet.)

W. — At **Forest Hills,** Suffolk County, 5 rails south of the south end of the New York, New Haven & Hartford Railroad depot platform, on the top at the west end of the south abutment of the bridge over Asticon Road. A brass disk. (16.604 meters or 54.475 feet.)

X. — At **Forest Hills**, Suffolk County, 2½ rails north of the New York, New Haven & Hartford Railroad depot, 25½ feet west of the west rail, 16 feet from the south end and 23¼ feet from the north end of the iron railing bounding the steps, and 3½ feet west of this railing. A concrete post with disk in top. (16.676 meters or 54.711 feet.)

R 2. — At **Roxbury,** Suffolk County, in the south end of the west abutment of the New York, New Haven & Hartford Railroad bridge over Tremont Street, 12 feet west of the west rail and 3 feet west of the south end of the iron fence extending south from the depot on the west side of the tracks. A brass disk. (11.498 meters or 37.723 feet.)

REPORT OF SPECIAL COMMITTEE

Appointed by the Board of Government to investigate Statements made by General Beach and Colonel Sherrill, of the Corps of Engineers, before the Joint Committee of Congress considering the Establishment of a Department of Public Works

Board of Government, Boston Society of Civil Engineers,
Boston, Mass.

Dear Sirs: — In accordance with a vote passed at the meeting of your Board on April 24, 1924, the undersigned were appointed a Committee to look into the facts in connection with certain statements of General Lansing H. Beach and Colonel Clarence O. Sherrill, of the Corps of Engineers, before the Joint Committee of Congress considering the reorganization of the administrative branch of the government.

Your Committee has obtained copies of the printed report of the hearings before the Joint Committee on the Reorganization of the Administrative Branch of the Government, on S. J. Res. 282, January 7 to 31, 1924.

The testimony of General Beach and Colonel Sherrill is given on pages 694 to 747, inclusive. This testimony sets forth the objections of these officers of the Engineers Corps of the United States Army to the establishment of a Public Works Department and the transfer thereto of certain activities now carried on by the Engineers Corps. In this testimony certain statements were made which constitute a serious reflection on the integrity and capacity of civilian engineers in construction work — as illustrated by their service during the recent war.

Excerpts from the testimony of Colonel Sherrill are as follows: —

> Had such an arrangement [the use of the Engineers Corps for building cantonments and other construction work] existed previous to the late European war, it is doubtful if the government would have been subjected to the *tremendous waste and graft* that was connected with the construction activi-

ties suddenly thrown upon the war Department without an adequate engineering organization in existence to handle the emergency.

. . . .

Take the *graft and absolute loss of funds through graft* to the government of over $80,000,000 in building camps. I feel no hesitation in saying that if that work had been under the Corps of Engineers, which as small as it was had the organization and the esprit de corps, that would never have happened; and, in fact, it did not happen in France where, under much greater difficulties, they did equally as great work without a single criticism.

. . . .

That [the Construction Division of the Quartermaster General's office] was in charge of General Marshall throughout the war, and if you will read the hearings before the Graham Committee you will find *tremendous graft* by people who did not have this training and that organization.

. . . .

I do not want to criticize General Marshall's decision, because when war breaks out you have to make decisions quickly, but if you have an organization *with a certain method of operation* you are not going to be so apt to make mistakes. If you had had this fine engineering organization and had thrown these reserve officers into active service under the same rules, you never would have had that trouble.

(*Note.* — *Italics* and bracketed insertions are ours.)

Colonel Sherrill has therefore charged that graft, waste, and inefficiency resulted from the employment of civilian engineers in the construction of camps.

As to graft — the incontrovertible answer is that *no graft has been proved.*

> Eleven suits against contractors who built cantonments have been brought by the government as well as an indictment for conspiracy against certain officials of the government responsible for much of the construction work during the war.
>
> The Supreme Court of the District of Columbia has dismissed the indictment against those charged with conspiracy, recording in its findings its opinion that desirable results have been accomplished. One suit — that against the contractor for Camp Travis — has been dismissed as not warranting trial. All findings by the courts in the other

cases to date have been in favor of the contractors. In no suit has the government yet been able to present a case on which trial could proceed.

As to the "tremendous waste" — all war is waste, and the building of the camps was done under war conditions. Colonel Sherrill, however, clearly intended to charge avoidable waste, and this we believe to be untrue.

> The paramount objective in the construction of the camps was completion on a specified date. The one inexcusable result was failure to complete on time. This condition necessitated the employment of labor, the acquirement of material, and the adoption of methods adapted to this one purpose of making the camps available on schedule, and economy inevitably became a secondary consideration.
>
> The labor available was limited, and all obtainable men had to be used with a resulting lowering of average individual output. The wages paid were fixed by regulation of Governmental Boards independent of the construction organization.
>
> Materials were generally purchased below the market and the acquirement of the necessary materials within the specified period was one of the outstanding achievements of the war.
>
> The simple answer to the charges of waste is that the work was done as cheaply as the emergency conditions made possible.

As to the efficiency and esprit de corps of the civilian engineers during the war — those of us who were connected with the Construction Division look back on the results obtained as the high point in our professional lives. We believe it is no exaggeration to say that no finer spirit or greater ability to adapt solutions to conditions was ever shown by any organization than that displayed not only by the engineers but by the contractors and their organizations in the building of the camps.

Speed and adaptability were the watchwords, and by these methods the civilian engineers made good.

In our opinion, any organization which attempted to use on this war work the methods and procedure which had been developed to meet the governmental peace-time conditions would have made a failure of its work, on which failure could not be tolerated. The methods used were as much responsible as were the men for the successful completion of these record-breaking jobs.

The keynote of the testimony of General Beach was an apparent attempt to show that the proposed establishment of a Public Works Department is a disguised effort to saddle on the government as standard procedure the cost plus a percentage type of contract. General Beach was evidently present while Colonel Sherrill was testifying.

Excerpts from General Beach's testimony are as follows: —

> Mr. Chairman and members of the committee, I desire to appear before the committee in regard to that feature of the proposed reorganization which deprives the Corps of Engineers of civil work and proposes to establish a Department of Public Works.
>
> The proposal to remove river and harbor works from the jurisdiction of the Corps of Engineers and to establish a Department of Public Works has arisen from time to time. It took rather concrete form a few years ago, about the close of the World War, and, as far as can be ascertained, it arose with certain civil engineers, engineering firms, and contractors, with a view to the creation of an independent department in which all construction work of the government of every kind should be centralized. The object of some of the more prominent parties in that movement was to fix the cost plus percentage system of contracts upon government works, and that idea has not been lost by a very large number of people still interested in that movement.
>
> . . . .
>
> I might just add that fully as much work was done of a similar character in France by the army during the war without a single cost-plus percentage contract, and this work was done in France under the Corps of Engineers.

We are informed that the Engineers Corps entered into a contract with the Phoenix Construction Company for the construction of wharves in France on a cost-plus 10 per cent basis. It is also a matter of record that contracts on a cost-plus basis were let during the war by the Engineers Corps for work done at Kearney, N. J., and at Norfolk, Va.

> General Beach: They [Chamber of Commerce of the United States] submitted arguments pro and con, and, if my recollection is correct, when the vote was taken two-thirds were opposed to the establishment of a Department of Public Works and one-third were in favor of it.
>
> . . . .
>
> That was the opinion of two-thirds of the Chamber of Commerce throughout the country.
>
> . . . .

The records show, we are informed, that the vote of the Chamber of Commerce was 827½ votes for and 549½ votes against the establishment of a Department of Public Works.

The reference of General Beach to the cost-plus type of contract, which was thoroughly justified under war conditions, is nothing more than an effort to draw a red herring across the trail of the real arguments for the establishment of the Public Works Department — which arguments are grounded on the development of greater co-ordination, efficiency and economy in this branch of the public service.

For engineers in position to know the facts, to besmirch their profession by making unfounded charges of graft and inefficiency shows a lack of that mental poise necessary to carrying on engineering work of other than routine nature.

For General Beach and Colonel Sherrill of the Engineers Corps to gratuitously slander the civilian engineer presents an additional danger, for it is on the civilian engineer that the country must rely for the expansion of the small peace-time Engineers Corps in time of war.

Having personal knowledge of some of the construction work indicted by these officers of the Engineer Corps, we resent for ourselves, and those who were associated with us, the insinuations of waste, graft and inefficiency. In our judgment, these men should be made to realize that they have placed themselves outside the bounds of professional conduct.

It is recommended that this report be published in the proceedings of the Boston Society of Civil Engineers, and that copies be sent to Secretary of War Weeks, General Beach, and Colonel Sherrill; and to the Senators and Representatives of this State in Congress; and to the engineering press.

Respectfully submitted,

Frank A. Barbour.
Chas. R. Gow.
F. M. Gunby, *Chairman.*

June 20, 1924.

MEMOIRS OF DECEASED MEMBERS

HIRAM ALLEN MILLER*

Hiram Allen Miller, the son of Charles Eliot and Emily (Clark) Miller, was born in Williston, Vt., June 3, 1853.

After attending a district school and a country academy he entered Yale College, taking a course in the Sheffield Scientific School, from which he graduated in 1876. His first engineering work after graduation was on railroad construction in the South and West, followed later by work on the Chicago Drainage Canal between 1892 and 1895, during which time he had charge of the construction of a section seven miles in length.

In October, 1895, he began work as department engineer, in charge of the construction of the Wachusett Reservoir for the Metropolitan Water Board of Boston, Mass. This work included the construction of earth dikes, and the relocation of railroads and highways.

At the conclusion of this work he was appointed Chief Engineer for the Charles River Basin Commission, in charge of the transformation of the lower portion of the Charles River between Boston and Cambridge from a tidal estuary with flats exposed at low water to a fresh-water lake, maintained at a constant level, with marked improvement of sanitary conditions. This work included a dam about one-quarter mile in length which carries a heavy traffic highway between Boston and Cambridge, a park area adjacent thereto, sluices to take care of the flood flow of the Charles River through the dam, a ship lock 350 feet long, 45 feet wide and 18 feet minimum depth, with rolling gates to take pressure in both directions, marginal conduits on both sides of the river to intercept storm sewer overflows from Boston and Cambridge and discharge them into the harbor below the dam, and an enbankment and park along the Boston shore for a distance of about one and one-quarter miles.

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* Memoir prepared by John L. Howard and Frank E. Winsor.

On the completion of this work he opened an office as consulting engineer in Boston, and was engaged on various private and public works in Massachusetts, Vermont and Connecticut. Perhaps the most important work with which he was connected during this period was the design and construction of the Farnham dam and reservoir, Pittsfield, Mass., and the necessary extension and enlargement of the water distribution system of that city.

During the world war he served as resident engineer of District No. 1 for the United States Shipping Board.

On October 7, 1884, Mr. Miller married Martha A. Buckingham of New Milford, Conn., who died July 4, 1914, leaving a daughter, Anna Irene Miller, now assistant professor of English literature at Goucher College, Maryland; and two sons, Buckingham, an engineer in New York City, and Hiram Allen, Jr., an engineer in Chicago. He again married on December 26, 1917, Bertha Marion Converse of Newton, Mass., who survives him.

Mr. Miller was elected a member of the Boston Society of Civil Engineers, February 19, 1896. He was a regular attendant at the meetings of the Society, and was always ready to give of his time and ability to advance its interests.

His unswerving integrity, his unfailing courtesy and his high appreciation of the ideals of his profession were impressed upon all his associates, and his wise counsel and helpful suggestions were always at the service of his assistants.

Two years before his death Mr. Miller submitted to a major surgical operation for intestinal trouble and never fully recovered his health thereafter. He died on November 2, 1923.

Mr. Miller was a member of the American Society of Civil Engineers, Boston Society of Civil Engineers, Western Society of Engineers, American Water Works Association, New England Water Works Association, American Forestry Association, Massachusetts Highways Association, Boston Chamber of Commerce, St. Botolph Club, Yale Club of Boston, and various historical and economic associations.

ARTHUR BATEMAN CORTHELL *

Arthur Bateman Corthell, the son of James H. and Charlotte Almy Corthell, was born on July 3, 1860, in Whitman, Mass. His father was a veteran of the Civil War.

Mr. Corthell was educated in the public schools of Providence, R. I., and entered Brown University in 1877, completing his course in March, 1881. At that time Brown University had no straight engineering course, but in 1898, by a special vote of the trustees of the University, he was awarded the degree of A.M.

During his college course he was employed on vacations, and at other times, as a draftsman for the Herreshoff Manufacturing Company of Bristol, R. I. As a result of his work here, on the design and construction of yachts, he became a very enthusiastic yachtsman, and throughout his entire life owned or sailed yachts whenever an opportunity presented itself.

Following his graduation from Brown University, Mr. Corthell was employed for a few months as a rodman in the City Engineer's office in Providence, but in September, 1861, he left there to take up railroad engineering as a profession, and he followed this work throughout his entire life.

His first work was with the New York, West Shore & Buffalo Railroad, where he was employed from September, 1881, to December, 1884, as assistant engineer on construction between Little Falls and Pittsford; then as supervisor on maintenance, and during the last year as division engineer of that part of the line between Syracuse and Buffalo.

Between December, 1884, and April, 1886, he worked with the Knickerbocker Ice Company of New York, making surveys and locations for the Rockland Lake Railroad and on miscellaneous engineering projects, returning again to the New York, West Shore & Buffalo Railroad early in 1886 where he worked as draftsman in the office of the chief engineer until the middle of the year.

In September, 1886, he entered the employ of the Fitzgerald & Mallory Construction Company, and, as principal

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* Memoir prepared by Frank C. Shepherd and Herbert S. Cleverdon.

assistant engineer for this concern, worked on the construction of about three hundred miles of new railroads in Kansas and Colorado for the Missouri Pacific System.

From July, 1887, to March, 1888, Mr. Corthell was employed as first assistant engineer on the construction of the Sioux City Bridge, over the Missouri River, this work carrying with it very heavy pneumatic foundation work, piers being sunk to a depth of 92 feet.

In 1888 and 1889 he was employed as assistant engineer on the construction of the Thames River Bridge and its approaches, at New London, Conn., having charge of the construction of the easterly half of the bridge foundations and the easterly approach, some five miles long, relocating and designing the masonry structures for same.

In 1889 he became assistant engineer of the New York, Providence & Boston Railroad, working on design and construction work, and in 1892 became first assistant engineer in charge of the design and construction of the Providence Terminal, with its approaches, being associated here with the late Mr. George B. Francis.

After the completion of the Providence Terminal, Mr. Corthell followed Mr. Francis to Boston, and was employed under him from 1897 to 1899 as principal assistant engineer on the construction of the South Station, Boston, one of the largest passenger terminals in the world.

On the completion of this station he worked for a few months with Westinghouse, Church & Kerr of Boston, returning in February, 1900, to the South Station, where for two years he was resident engineer for the Boston Terminal Company, leaving there in February, 1902, to accept a position with the New York Central Railroad.

From 1902 to July, 1911, he was with the New York Central Railroad, working as terminal engineer for four years; assistant executive to the Grand Central Station architects for two years, and the last three years as secretary and consulting engineer of the Auxiliary Facilities Committee of the Grand Central Terminal.

From his association with Mr. Francis and his experience at Providence and Boston Mr. Corthell became known as one of the leading experts in the country on terminal developments, and this undoubtedly largely influenced his selection for the above position.

Under his direct supervision the original plans of the Grand Central Terminal improvements were developed and he was largely instrumental, not only in the preparation of the final plans but also in the carrying out of the work towards its completion, it being said of his relations with many associates in the planning and construction of this great terminal that it was largely due to his efforts that the work went on harmoniously and without delay.

In 1911 Mr. Corthell became chief engineer of the Boston & Maine Railroad, being selected for this position because of the large construction plans contemplated at that time, a number of which were actually carried out.

This position he filled until his sudden death on May 24, 1924, while spending the week-end at his farm in New Boston, N. H.

As a boy, Mr. Corthell was a member of the choir of Trinity Church, Bristol, R. I., and always, during his life, was a great lover of music.

He was an enthusiastic Mason, being affiliated with Orpheus Lodge of Providence, R. I., and was also a member of the Massachusetts Consistory.

He was a member of the Protestant Episcopal Church and at the time of his death had been a vestryman of the Church of the Epiphany, in Winchester, Mass., for some years.

Mr. Corthell was a man of unusual character and integrity, had a very quick, keen mind, and his ability was fully recognized in his profession as well as by the railroad executives under whom he was employed.

He was a man of many friends, and one who was greatly beloved by all who ever became associated with him, and his death is a distinct loss to the engineering profession.

He is survived by his wife, Mrs. Lena Foster Corthell; his daughter, Mrs. John T. Phelps; and two sons, Mark A. and Edwin L. Corthell, as well as by his father and mother.

Mr. Corthell was elected a member of the Boston Society of Civil Engineers on January 25, 1899, and was also a member of the American Society of Civil Engineers, American Railway Engineering Association, the New England Railroad Club, and the Vesper Country Club of Lowell, Mass.

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BOSTON SOCIETY OF CIVIL ENGINEERS

FOUNDED 1848

PROCEEDINGS

MINUTES OF MEETINGS

Boston Society of Civil Engineers

June Outing. — Although the unfavorable weather conditions on Saturday, June 14th, 1924, made it necessary to cancel the boat ride and the outing features, the inspection trip to the new Weymouth power station of the Edison Electric Illuminating Company and the Fore River Plant was carried out amid the rain. About seventy-five members took part, some arriving by auto and the others by train and trolley. The party was divided into two groups, one group being conducted by competent guides over the plant of the Edison Company, while the other party went directly to the Fore River Plant where they were taken over the new Airplane Carrier "U. S. S. Lexington," which was in the process of construction. Later, the parties were interchanged, although some of the members had devoted so much time to seeing the Edison Plant that they were unable to take in the trip to the Fore River Plant. It is hoped that there will be an opportunity to visit the Edison station at a later date, when it is in actual operation.

J. B. Babcock, *Secretary.*

APPLICATIONS FOR MEMBERSHIP

[Sept. 15, 1924.]

THE By-Laws provide that the Board of Government shall consider applications for membership with reference to the eligibility of each candidate for admission and shall determine the proper grade of membership to which he is entitled.

The Board must depend largely upon the members of the Society for the information which will enable it to arrive at a just conclusion. Every member is therefore urged to communicate promptly any facts in relation to the personal character or professional reputation and experience of the candidates which will assist the Board in its consideration. Communications relating to applicants are considered by the Board as strictly confidential.

The fact that applicants give the names of certain members as reference does not necessarily mean that such members endorse the candidate.

The Board of Government will not consider applications until the expiration of twenty (20) days from the date given.

For Admission

DEL GROSSO, HORACE A., Boston, Mass. (Age 33, b. Boston, Mass.) Graduate of high school, two years at M. I. T., also studied engineering subjects at evening school, Franklin Union. Has been in responsible charge of field construction for five years; three years on irrigation project; one and one-half years on hydro-electric work; has also had experience in industrial buildings and foundations. At present in the contracting business as junior partner and acting as superintendent of construction and estimator. Refers to Robinson Abbott, H. A. Gray, H. F. Heald, H. F. Marnell, J. F. Osborn.

KHAN, SHABBIR A., India. (Age 39, b. Moradabad, U. P.) Has privately gone through entire course of civil engineering as well as structural engineering, and has acquired experience by working for nineteen years at designing and construction of buildings, bridges, dams, weirs, surveying, leveling, as draftsman, also in public works department. Since February has held office of executive engineer in Rampur State. Testimonials accompany application.

STILES, RANSOM WENTWORTH, Boston, Mass. (Age 18, b. Boston, Mass.) Has worked for thirteen months with the New York, New Haven & Hartford Railroad as head chainman, and has had some experience with a transit. Refers to G. C. Barry, C. R. Berry, W. W. Davis, H. F. Marnell, H. T. Stiff.

LIST OF MEMBERS

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Fox, Vernald W. . . 10 Grove St., North Attleborough, Mass.
Hadley, Norris E. . . 35 Conwell Ave., West Somerville, Mass.
Harriman, Henry I. . . . . 50 Congress St., Boston, Mass.
Hutchins, Everett N. . . . . 706a Main St., Malden, Mass.
Kitfield, Philip H. . . . 121 Elmwood Rd., Swampscott, Mass.
Mitsch, J. Donald . . . 10 Hazleton St., Mattapan, Mass.
O'Leary, Leo T. . . . 2 Davidson Ave., Dorchester, Mass.
Proctor, Clarence D. . . . 42 Tennyson St., Somerville, Mass.
Quinn, Francis B. . . . . 11 Simonds Ct., Medford, Mass.
Waldman, Julius J. . . . 143 Franklin Ave., Chelsea, Mass.
Willey, Clyde C. . . . 34 St. Stephens St., Boston, Mass.

Changes of Address

Burrage, Henry T. . . . . 15 Ellery St., Cambridge, Mass.
Carter, Clarence E. . . Room 407, 14 Beacon St., Boston, Mass.
Chase, Horace H. . . . 610 West 146th St., New York, N. Y.
Cronin, William H. . . . 94 Marathon St., Arlington, Mass.
Flynn, Francis T. . . . 7 Waterlow St., Dorchester, Mass.
Gow, Charles R. . . . 1751 Beacon St., Brookline, Mass.
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McCarthy, Edward R. . . . 11 Lincoln St., Natick, Mass.
Sylvia, Manuel H. . Supt., Brazilian Tel. Co., Rua 7 de Abril, No. 67,
Sao Paulo, Brazil, S. A.

LIBRARY NOTES

Book Review

"Reinforced Concrete and Masonry Structures." Compiled by a staff of specialists. Editors-in-Chief: George A. Hool, Consulting Engineer. Professor of Structural Engineering, University of Wisconsin; and W. S. Kinne, Professor of Structural Engineering, University of Wisconsin. First edition. McGraw-Hill Book Company, Inc., New York. 786 pp.

Reviewed by Howard A. Gray*

This book, designed to provide the engineer and the student with a reference work covering the design and construction of structures in the materials indicated by its title, has been compiled by a staff of fourteen specialists.

The several sections into which the text is divided cover the preparation and placing of concrete, forms for concrete. bending and placing concrete reinforcement, finishing concrete surfaces and waterproofing, reinforced concrete buildings, retaining wall design, slab and girder bridges, arches, hydraulic structures, chimneys, concrete detailing and estimating concrete costs. The book has seven appendices, which include standard specifications for Portland Cement, standard method of test for organic impurities in sands for concrete, method of test for quantity of clay and silt in sand, method of test for unit weight of aggregate for concrete, specifications for concrete reinforcement bars, 1921 Progress Report of New Joint Committee and strength of stone masonry.

This text records present day practice in the art of concrete design, bringing up to date the literature of Reinforced Concrete, thus meeting a real need.

It is difficult to conceive how this compilation could be improved upon, either as to clearness of exposition or material included. The minute detail of certain sections, compared with the general discussion in others, reminds one quite forcibly, however, of the different authorships of the several sub-divisions.

The sections on Reinforced Concrete Buildings, Arches and Chimneys are very complete and deserve special mention.

---

* Engineer, Morton C. Tuttle Company, Park Square Building, Boston, Mass.

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U. S. Government Reports

Inland Water Transportation in U. S. 1923. Dept. of Commerce.

Interstate Commerce Commission Reports. 1917, 1920, 1922, 1923.

Mineral Resources of United States. 1918–21 incl.

Mortality Statistics. 1922. U. S. Bureau of Statistics.

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Gas and Fuel Analysis for Engineers. Gill.

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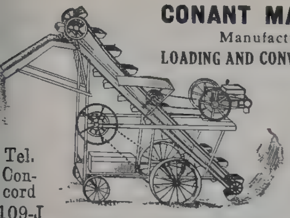
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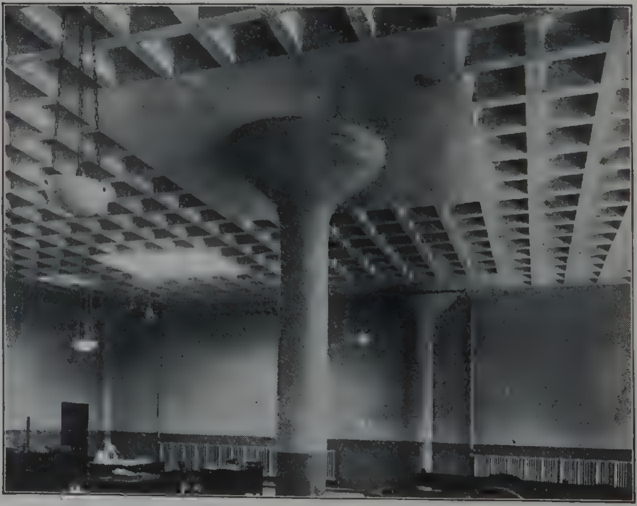

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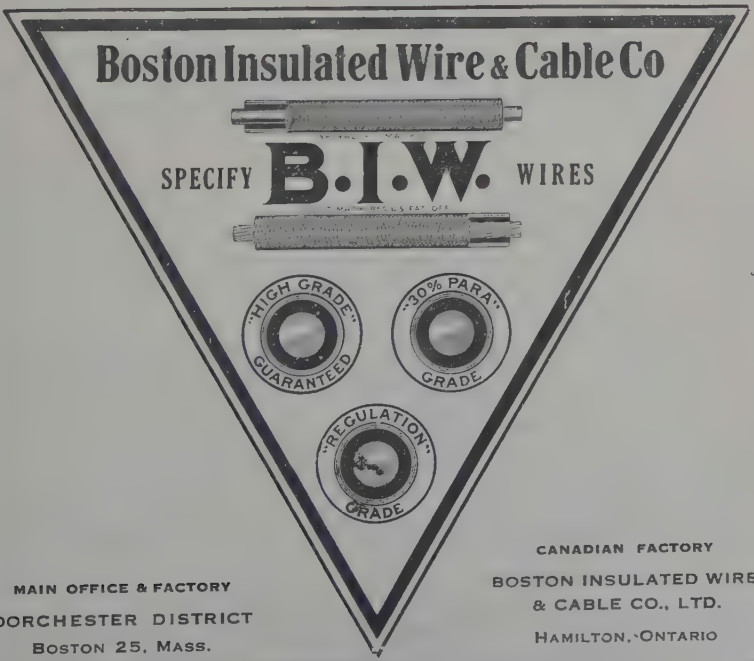

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